Climate changes expose organisms to novel environmental conditions with the potential to affect the life history and demography of individuals. If they are to stay alive and reproduce, organisms must be able to cope with such environmental changes—not least with (changing) environmental stochasticity. The expression of individual traits in variable environments provides a mechanism that links variable environments and parameters such as survival and reproduction. After all, how well a species is able to cope with environmental changes depends on its potential to adapt to new environmental conditions.

Some of the most striking examples of rapid changes in life-history traits due to climate change are found in migratory birds, especially in the timing of migration and breeding. Migrating birds are at the center of the public’s fascination for birds, a general interest in the phenomenon of migration, and the long history of systematic recording of arrival and departure of migratory birds. This has generated a wealth of potentially valuable data that can shed light on how bird-migration patterns are affected by climate change and variability. The general picture emerging shows that, for many species breeding in the northern hemisphere, spring arrival has advanced during the second half of the 20th century and similar patterns have recently been described in Australia. The direction of the observed changes is in agreement with global changes in spring temperature; however, detailed data revealing the underlying mechanisms have rarely been available.

In the recent contribution of Working Group II to the IPCC Fourth Assessment Report, it is stated with high confidence that “Climate and ecosystems are very likely to show a wide range of vulnerabilities to climate change, depending on the nature of exposure to ecosystem-specific, critical thresholds.” The wide range of vulnerability as highlighted by the IPCC is mirrored by the inter-specific variation in changing phenology patterns shown by migratory birds in the last few decades. Focusing on arrival time only, there is considerable variation among species despite the general trend towards earlier arrival. Moving beyond the simple demonstration of earlier spring migration, some recent systematic studies of the timing of arrivals suggest that if we are to understand the nature of variation both within and between species. In order to identify the ways in which birds can adapt to climate change, we need to investigate such issues as the extent to which adaptation differences reflect systematic differences in the strategies, food preferences or taxonomic grouping of birds. The migration schedule of birds will be modulated by the environmental conditions experienced throughout the migratory journey. Both & te Marveldt investigate how spatiotemporal spring temperature patterns affect geographical variation in laying date in 2 contrasting species, one spending the winter in Europe and the other migrating through Africa. Analysis of the data on timing of spring migration. Considerably less is known about how climate change has affected autumn migration phenology. A contribution to the field is given by Pérón et al., who analyse the timing of post-nuptial migration and stopover strategy in 2 insectivorous passerine species. The last 2 contributions provide a fresh reminder of the complexity of the problem at hand: to understand and predict the ecological ramifications of climate change.

If we increase the resolution and go beyond the arrival patterns based on the mean response of a number of arrival dates and how the response to temperature may change over time. In the final paper, Mustin et al. use migratory shorebirds as an example and discuss whether it is possible to predict the consequences of climate change at the species level that are difficult to include.

The temporal shifts in migratory phenology have already been well described, at least for spring arrival in Europe and North America, and now is the time to delve into the underlying processes. Before do that, let us have a closer look at the (rather) general patterns described so far. Rubolini et al. analysed data from both passerines and non-passerines. Overall there were rapid advances in arrival date, especially for first arrival dates in species spending the winter in Europe. The most important finding reported by Rubolini et al. was that change in spring arrival date shows a significant degree of intraspecific consistency, and can thus be regarded as a species-specific trait. In other words, different populations respond in the same way in their response to climate change simply because they are exposed to the warming in Europe all year round. The long-distance migrants, on the other hand, are only affected by warming while migrating through Europe, and any advancement to central or northern Europe would reflect the improved environmental conditions en route. Therefore, the adaptation of breeding timing could only take place if the development of optimal conditions may be constrained by the migration strategy in long-distance migrants. We think that it is time to revise some details of that picture. Though the importance of endogenous control and photoperiod as

Bird Migration and Climate Change

Niclas Jonzén, Torbjörn Ergon, Andreas Lindén and Nils Christian Stenseth

Climate changes expose organisms to novel environmental conditions with the potential to affect the life history and demography of individuals. If they are to stay alive and reproduce, organisms must be able to cope with such environmental changes—not least with (changing) environmental stochasticity. The expression of individual traits in variable environments provides a mechanism that links variable environments and parameters such as survival and reproduction. After all, how well a species is able to cope with environmental changes depends on its potential to adapt to new environmental conditions.

Some of the most striking examples of rapid changes in life-history traits due to climate change are found in migratory birds, especially in the timing of migration and breeding. Migrating birds are at the center of the public’s fascination for birds, a general interest in the phenomenon of migration, and the long history of systematic recording of arrival and departure of migratory birds. This has generated a wealth of potentially valuable data that can shed light on how bird-migration patterns are affected by climate change and variability. The general picture emerging shows that, for many species breeding in the northern hemisphere, spring arrival has advanced during the second half of the 20th century and similar patterns have recently been described in Australia. The direction of the observed changes is in agreement with global changes in spring temperature; however, detailed data revealing the underlying mechanisms have rarely been available.

In the recent contribution of Working Group II to the IPCC Fourth Assessment Report, it is stated with high confidence that “Climate and ecosystems are very likely to show a wide range of vulnerabilities to climate change, depending on the nature of exposure to ecosystem-specific, critical thresholds.” The wide range of vulnerability as highlighted by the IPCC is mirrored by the inter-specific variation in changing phenology patterns shown by migratory birds in the last few decades. Focusing on arrival time only, there is considerable variation among species despite the general trend towards earlier arrival. Moving beyond the simple demonstration of earlier spring migration, some recent systematic studies of the timing of arrivals suggest that if we are to understand the nature of variation both within and between species. In order to identify the ways in which birds can adapt to climate change, we need to investigate such issues as the extent to which adaptation differences reflect systematic differences in the strategies, food preferences or taxonomic grouping of birds. The migration schedule of birds will be modulated by the environmental conditions experienced throughout the migratory journey. Both & te Marveldt investigate how spatiotemporal spring temperature patterns affect geographical variation in laying date in 2 contrasting species, one spending the winter in Europe and the other migrating through Africa. Analysis of the data on timing of spring migration. Considerably less is known about how climate change has affected autumn migration phenology. A contribution to the field is given by Pérón et al., who analyse the timing of post-nuptial migration and stopover strategy in 2 insectivorous passerine species. The last 2 contributions provide a fresh reminder of the complexity of the problem at hand: to understand and predict the ecological ramifications of climate change. Sparks & Tryjanowski study changes in the timing of arrival dates and how the response to temperature may change over time. In the final paper, Mustin et al. use migratory shorebirds as an example and discuss whether it is possible to predict the consequences of climate change at the species level that are difficult to include.

The temporal shifts in migratory phenology have already been well described, at least for spring arrival in Europe and North America, and now is the time to delve into the underlying processes. Before do that, let us have a closer look at the (rather) general patterns described so far. Rubolini et al. analysed data from both passerines and non-passerines. Overall there were rapid advances in arrival date, especially for first arrival dates in species spending the winter in Europe. The most important finding reported by Rubolini et al. was that change in spring arrival date shows a significant degree of intraspecific consistency, and can thus be regarded as a species-specific trait. In other words, different populations respond in the same way in their response to climate change simply because they are exposed to the warming in Europe all year round. The long-distance migrants, on the other hand, are only affected by warming while migrating through Europe, and any advancement to central or northern Europe would reflect the improved environmental conditions en route. Therefore, the adaptation of breeding timing could only take place if the development of optimal conditions may be constrained by the migration strategy in long-distance migrants. We think that it is time to revise some details of that picture. Though the importance of endogenous control and photoperiod as
a trigger of migratory restlessness is beyond doubt, a growing number of studies point at the importance of interannual variation in winter climate as a predictor of arrival time in the summer quarters. Hence, the timing of migration may be pretty flexible even in long-distance migratory birds, and the detailed studies of the American redstart suggest that not only the speed of migration, but also the departure date can be affected by winter climate through its effect on habitat quality and thus the time needed to prepare for migration.

There are also observations that are not easily explained by a simple phenotypic response. For instance, the earlier arrival of African migrants on Capri cannot be fully explained by the climatic variables investigated so far. It has been suggested that the lack of explanation for the advanced arrival on Capri may be an indication of micro-evolution, but there are potential pitfalls to making premature claims about micro-evolution. Another interesting observation that is not easily attributed to phenotypic plasticity only is the increased response to temperature in SW Europe in the sand martin, Riparia riparia, which has resulted in earlier arrival in the UK at the same temperature as before. Again, the data at hand do not allow any formal test of the involvement of any micro-evolutionary processes, but they cannot be excluded either.

One may ask why we still lack conclusive evidence for evolutionary change despite selection for earlier arrival and the presence of genetic variation in the timing of migration, and plausible answers to this critical question are given by Pulido (2007). To some extent it is a data problem. Based on arrival data from bird observatories, we are not in position to differentiate between the relative roles of phenotypic plasticity and evolutionary responses, data do not unambiguously support or refute either of the two (not mutually exclusive) hypotheses. Interannual arrival data on individual birds, measured with high precision, would be useful for this purpose. Unfortunately, those kind of data are very scarce. However, there are other reasons why it is inherently difficult to find conclusive evidence for micro-evolution. For instance, to what extent changes in wind directions and speed can explain the earlier arrival of migratory birds is largely unexplored. Furthermore, since the physical condition of birds can affect departure time, we clearly need experimental studies on the wintering grounds to better understand the importance of carry-over effects that may persist over several generations. Hence, we need to appreciate the whole life cycle of events and not only to study spring migration as an isolated phenomenon. In that respect, the timing of autumn migration and how it relates to the timing of spring migration, and the selection pressures involved is, of course, of interest and has not received the attention it deserves.

In conclusion, we are now moving beyond the mere description of patterns and starting to think about the underlying mechanisms. Therefore, it is not surprising that we find ourselves in a situation where the importance of different processes (e.g. phenotypic plasticity and micro-evolution) are being discussed, but no consensus has yet emerged. Theoretical modelling may help us to get a better idea about the selection pressures involved in adapting to climate change and to know what to expect. However, as several of the contributed papers have pointed out, what we also need are more individual-based data and clever experiments to reveal the relative importance of the range of processes affecting how climate change shapes the timing of biological events, and consequently, the distribution and abundance of organisms.

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A New Conservation and Development Frontier: Community Protected Areas in Oaxaca, Mexico

David B. Bray, Elvira Duran, Salvador Anta, Gary J. Martin and Fernando Mondragón

Most protected areas in the world are managed by people. Recent figures suggest that around 11.5% of the global terrestrial area is under some form of protection but about 90% of these protected areas are in IUCN categories III-VI that allow degrees of human presence and use. In addition, some 11% of forests globally have been devoted to local communities to varying degrees by governments. Thus, the vast majority of protected areas in the world have human presence in them, although frequently with unclear rights to forests and their products when they are present.

Mexico is at the forefront of countries where local communities have direct ownership rights of their forests, with an estimated 56-80% of national forests directly owned by communities, within which extraction activities are regulated by Mexican environmental law. This process of devolution occurred as a result of a sweeping agrarian reform that took place through most of the 20th century. One outcome of this devolution has been that Mexican forest communities have gained decades of experience in managing their forests for the commercial production of timber. A recent paper reported that about 2300 communities have commercial logging permits with varying degrees of vertical integration and sustainable forest management.

However, not all Mexican forest communities have commercially valuable forests and others have forest areas that are mostly inaccessible. Further, the dominance of community ownership of rural lands means that there are few opportunities for expansion of Mexico’s protected public areas that do not conflict with pre-existing community ownership. These realities have led some communities to become pioneers in taking advantage of a new policy opening from the Mexican government, the possibility of officially recognized protected areas on community owned lands. According to government figures, 34 community protected areas have been recognized by the National Commission of Natural Protected Areas (CONANP) since 2003. Of these 34, 13 are in indigenous communities, and 12 of these 13 are in the state of Oaxaca, with several clustered in the Sierra Norte region. Further, a recent study by one of the co-authors and his colleagues found that Oaxacan communities are, in addition, informally protecting 236 ‘voluntary conservation areas’ (an area of about 240,000 ha). The authors, in

Photo: David Barton Bray